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Influence of Asphalt Source, Polymer Modification and Geotextile Interlayers on Cracking Performance in Hot Mix Asphalt Pavements

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Abstract

Non-load associated cracking in asphalt pavements has long been associated with properties of the asphalt binder (1, 2, 3, 4). However, the properties of the binder that describe this behavior are not well understood (5). Although softer asphalt binders are often specified in cold regions to reduce the potential for cracking, this simple approach is often not acceptable since plastic deformation can then result. Various polymers have been used to modify asphalts to impart elastic properties at high temperatures while retaining plastic properties at low temperatures (6). However, the specifications for these modified asphalts are often proprietary and not useful to public agencies requiring a generic specification. Therefore, in 1987 the New Mexico Department of Transportation sponsored a research project to evaluate the performance of several polymers in asphalt to determine the effects on cracking over the long term. A controlled, full-scale experiment was designed and constructed to evaluate the long-term performance of these admixtures at two levels of modification each. Control sections were constructed in conjunction with each polymer section resulting in a total of fourteen test sections in the westbound direction of the two-lane facility. In addition, test sections to compare fabric interlayer performance were added during construction in the eastbound lanes. These fourteen test sections include pavement overlay with fabric as an interlayer and without fabric as an interlayer (7). Results of this research indicate that while differences exist in cracking performance between the different polymer modifiers, differences between fabric interlayer and non-interlayer sections are more significant and the difference in cracking performance between the unmodified westbound lanes and the unmodified eastbound lanes is very significant and may be linked to the source of the asphalt utilized. Traditional methods to predict cracking using temperature susceptibility indices of PI and PVN may be useful for unmodified asphalts but appear inconsistent with polymer modified asphalts.

Keywords
Asphalt pavement cracking, long-term pavement performance, geotextile interlayer, quality improvement

1. Introduction

Non-load associated cracking in asphalt pavements has long been associated with properties of the asphalt binder (1, 2, 3, 4). However, the properties of the binder that describe this behavior are not well understood (5). Although softer asphalt binders are often specified in cold regions to reduce the potential for cracking, this simple approach is often not acceptable since plastic deformation can then result. Various polymers have been used to modify asphalts to impart elastic properties at high temperatures while retaining plastic properties at low temperatures (6). However, the specifications for these modified asphalts are often proprietary and not useful to public agencies requiring a generic specification.

Therefore, in 1987 the New Mexico Department of Transportation sponsored a research project to evaluate the performance of several polymers in asphalt to determine the effects on cracking over the long term. A controlled, full-scale experiment was designed and constructed to evaluate the long-term performance of these admixtures at two levels of modification each. Control sections were constructed in conjunction with each polymer section resulting in a total of fourteen, approximately 0.75 mile (1.2 km) test sections in the westbound direction of the two-lane facility. Fourteen additional 0.75 mile (1.2km) test sections to compare fabric interlayer performance were added during construction in the eastbound lanes. These fourteen test sections include pavement overlay with and without fabric (7).

The condition of the pavement was assessed in 1987 prior to rehabilitation. Cracking, raveling, and rutting were measured and provide a baseline for future condition surveys. A new condition survey was conducted on July 24 and 25, 2005. The cracking observed after eighteen years is compared with the original cracking and serves as the basis for this paper. The condition of each test section was recorded by measuring the length of each type of crack observed using a measuring wheel for each of five, one hundred foot segments within each test section. The process used was the same as the process used in 1987 to record the pavement condition before the overlay was applied.

2. Project Location

The project was constructed on US64 west of Cimarron, NM and east of Ute Park, NM as shown on Figure 1. The location is a high alpine environment at approximately 6700 feet (2042 m) mean sea level.

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TIFF (LZW) decompressor
are needed to see this picture.

Figure 1. Test Road Location

3. Materials

The asphalt mixture utilized for rehabilitation of the existing asphalt pavement was a conventional New Mexico DOT dense graded hot mix asphalt with properties shown in Table 1.

Table 1. Properties of Hot Mix Asphalt Utilized for Overlay

Sieve	**Passing, %**
½” (12.5 mm)	100
3/8” (9.5 mm)	90
No. 4 (4.75 mm)	65
No. 8 (3.35 mm)	45
No. 50 (	20
No. 200 (0.75mm)	5
Air Voids, %	4.2
VMA, %	14.5
Marshall Stability, lbs	3750
Marshall Flow, 0.01 in	14

The mixture shown in Table 1 was placed over the existing asphalt pavement three inches (75 mm) thick. The binder used in the westbound lane was a 120-150 penetration grade asphalt cement from the Navajo Refinery in Artesia, NM. Polymers used to modify the asphalt in the westbound lane were a block copolymer of styrene and butadiene from Shell Chemical (Kraton D4463X), a second Shell block copolymer known as Kraton D1101 modified using the Styrelf process by Elf Asphalt, and an ethylene vinyl acetate from Dupont called Elvax 150W. Properties of the asphalt and modified asphalt at the respective concentrations by weight are shown in Table 2.

Table 2. Properties of Navajo Asphalt Binders in Westbound Lane

	Control 120-150	Kraton, 3%	Kraton, 6%	Styrelf, 3%	Styrelf, 6%	Elvax, 2%	Elvax, 4%
Penetration, 77F, (25C)	127	171	144	138	115	135	129
Penetration, 39.2F (4C)	34	55	67	39	42	35	40
Viscosity, P, 140F (60C)	439	739	na	739	na	374	513
Viscosity, cSt, 275F (135C)	156	329	550	293	693	219	308
Softening Point, F (C)	114	124	180	116	128	110	113
Rotational Recovery, %, 77F (25C)	0	14	40	5	44	3	6
Penetration Index	2.70	3.80	6.75	3.01	4.69	2.52	3.57
PVN	-1.43	0.15	0.76	-0.32	0.81	-0.82	-1.70

Eastbound test sections consisted of an asphalt concrete overlay using the asphalt shown in Table 3 placed over a 90 psi (620 kPa) geotextile fabric. Adjacent control sections were placed next to the test sections along the eight mile alignment with no geotextile under the asphalt overlay.

Table 3. Properties of Diamond Shamrock Asphalt Binder in Eastbound Lane

	Control 85-100
Penetration, 77F, (25C)	95
Penetration, 39.2F (4C)	28
Viscosity, P, 140F (60C)	965
Viscosity, cSt, 275F (135C)	365
Softening Point, F (C)	125 (52)
Rotational Recovery, %, 77F (25C)	0
Penetration Index	3.25
PVN	-0.42

4. Experiment Design

Control sections were placed alternately with corresponding polymer modified test sections along the alignment for performance comparison. Therefore, the resulting test pavement consists of six different polymer modified sections with six adjacent control sections for a total of approximately eight miles (13 km) as shown in Figure 2.

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TIFF (LZW) decompressor
are needed to see this picture.

Figure 2. Test Section Arrangement

5. Results

The average cracking observed during the 2005 field survey is shown in Figures 3 through 5 for the westbound lanes and Figures 6 through 8 for the eastbound lanes.

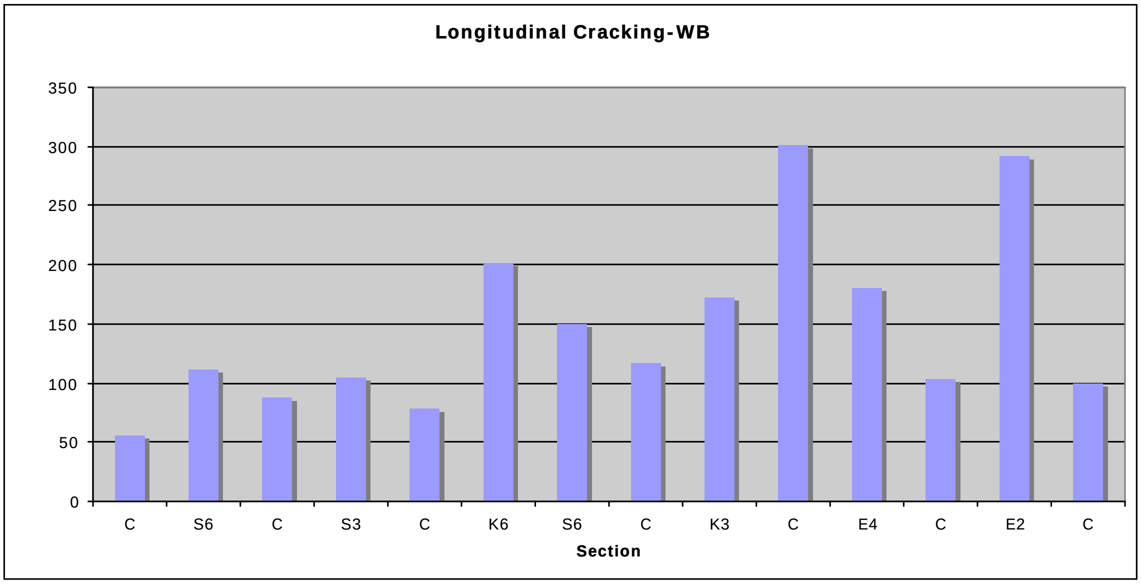

Figure 3. Longitudinal Cracking Westbound ('C' indicates control, 'S6' indicates Styrelf 6%, etc.)

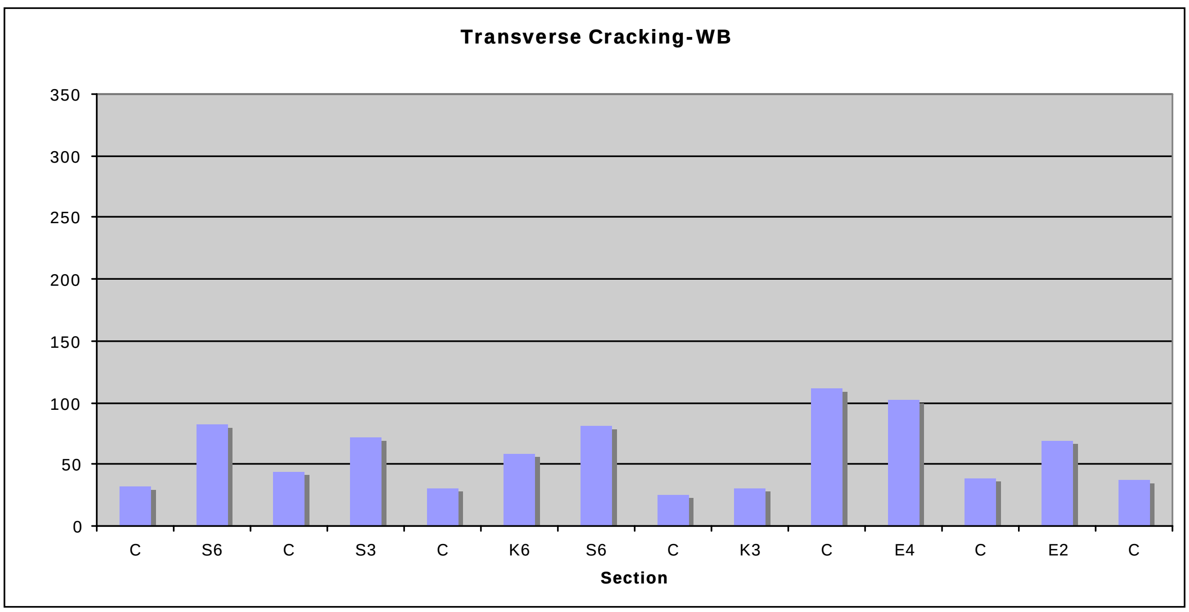

Figure 4. Transverse Cracking Westbound

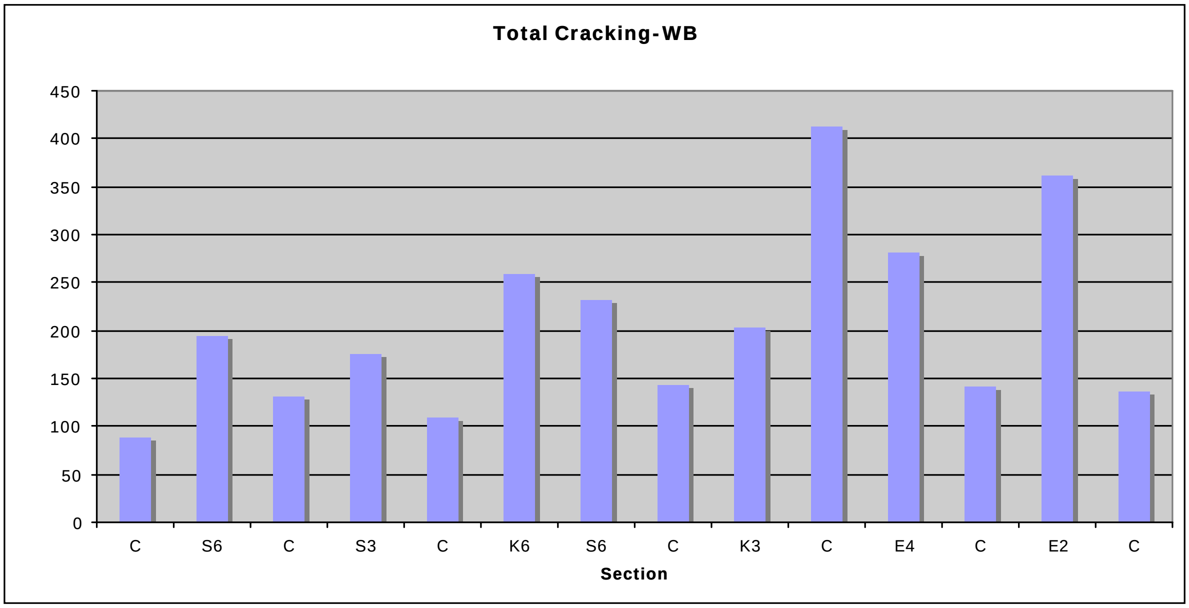

Figure 5. Total Cracking Westbound

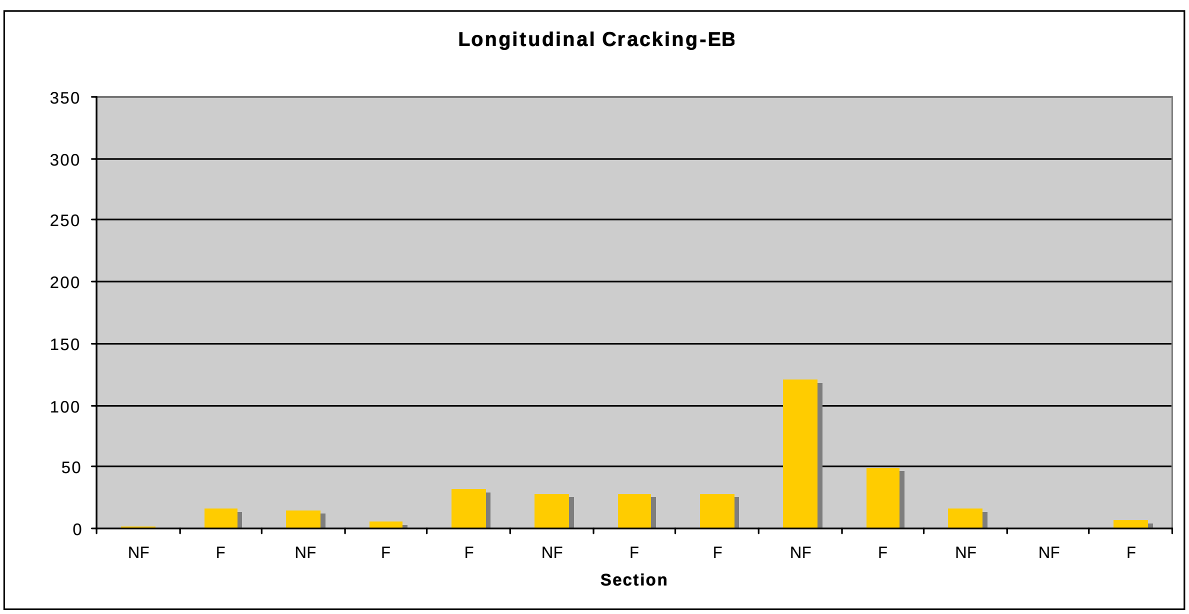

Figure 6. Longitudinal Cracking Eastbound ('NF' indicates no fabric, 'F' indicates fabric)

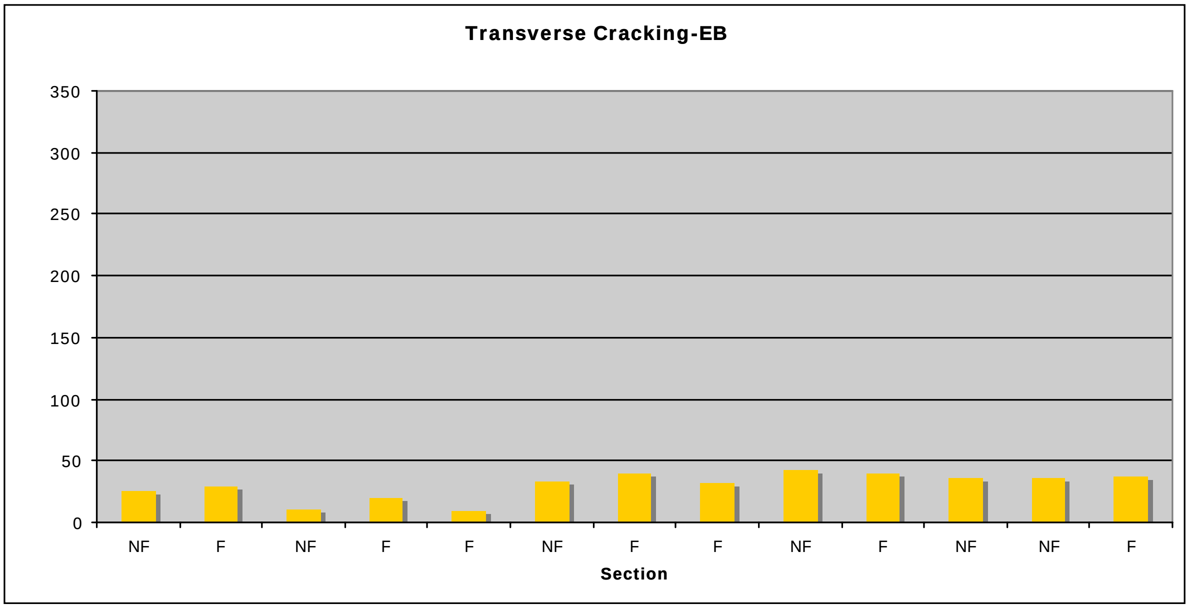

Figure 7. Transverse Cracking Eastbound

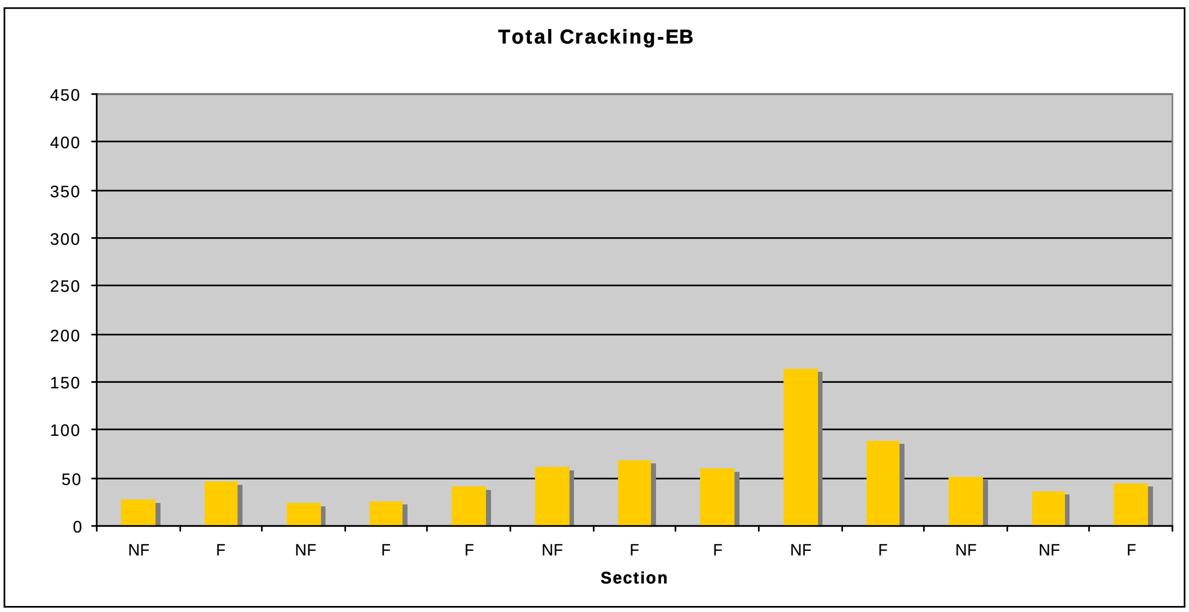

Figure 8. Total Cracking Eastbound

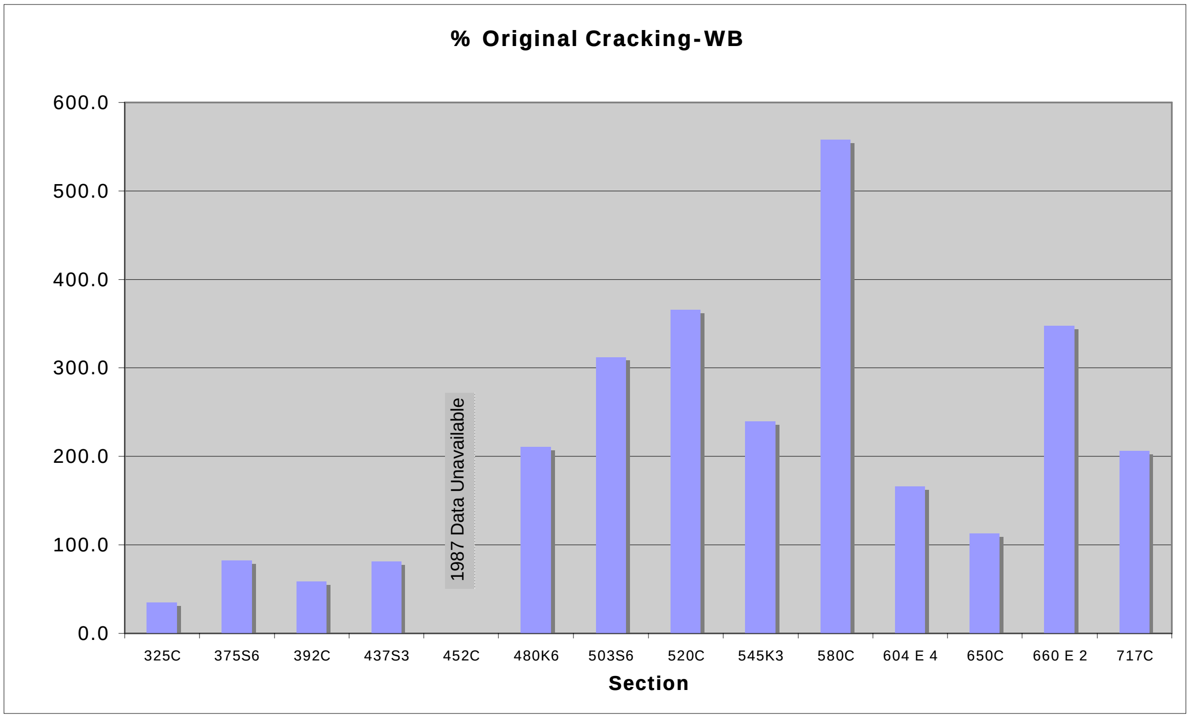

Figure 9. Percent of Original Total Cracking Westbound (numbers preceding letters are station locations in feet)

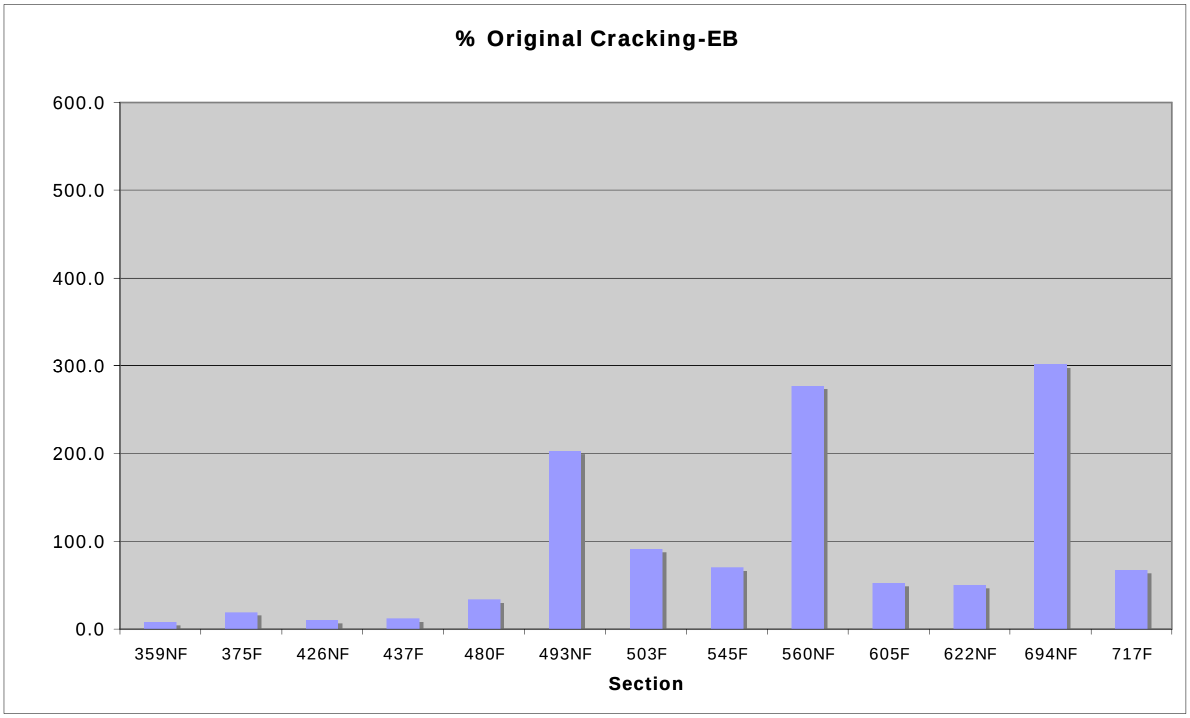

Figure 10. Percent of Original Cracking Eastbound

6. Analysis

Westbound

The total cracking measured in the westbound lane appears to be greater for the polymer modified test sections than the control sections as shown in Figure 4. Every control section had fewer total cracks, as well as fewer longitudinal and transverse cracks, than the corresponding polymer modified test sections as shown in Figures 3 through 5. When 2005 cracking is compared with cracking existing in 1987, a similar trend occurs. This is contrary to the temperature susceptibility indices measured by the penetration index and penetration-viscosity number as the control asphalt appears more temperature susceptible than any of the polymer modified asphalts except the Elvax at 2 percent for PI and Elvax 4 percent for PVN. Five of the seven control sections outperformed corresponding polymer modified test sections with respect to the percentage of original cracks. Of the polymer modified test sections, two of the Styrelf sections performed somewhat poorer than corresponding control sections displaying approximately the same number of cracks in 2005 as were present in 1987. The other polymer modified sections performed much worse with an average of slightly less than two times the 1987 cracking for the Kraton test sections and an average of over two times the 1987 cracking for the Elvax modified sections.

Eastbound

Three of the six pairs of control and test sections had fabric sections performing much better than adjacent non-fabric sections. The other three pairs of test and control sections performed equally.

Westbound vs Eastbound

The eastbound lane is performing significantly better than the westbound lane. Only three of the thirteen sections eastbound displayed greater than 100 percent of the original total cracking. The average percent original cracking eastbound is 98 percent compared with 213 percent westbound. Temperature susceptibility values for the unmodified asphalts appear to support this result. The westbound 120-150, although softer, is more temperature susceptible (PI=2.70, PVN=-1.43) than the eastbound 85-100 (PI=3.25, PVN=-0.42).

7. Conclusions

1. The polymer modified test sections appear to be performing poorer than corresponding control sections in the westbound lanes for five of seven control sections.

2. While the Styrelf sections are not performing as well as the corresponding control sections, they may be performing better than the other polymer modified test sections. However, two Styrelf 6% sections were placed. One section is displaying approximately 80 percent of the original cracking while the second section is displaying 300 percent of the original cracking. Therefore, it is difficult to say without further data whether the Styrelf is performing better than the other polymer modifiers. Further evaluation of the pavement from these sections is planned to help provide this information.

3. The geotextile interlayer placed in the eastbound lanes is performing better than corresponding control sections in about half of the pairs evaluated. Further evaluation of the pavement is planned to help explain these differences.

4. The eastbound lane is performing significantly better than the westbound lane with less than half the cracking displayed in the westbound lane. The most immediate and apparent reason for this difference is the source of the asphalt binder used. The 85-100 asphalt from Diamond Shamrock, although a harder binder than the 120-150 from Navajo demonstrated less temperature susceptibility during initial laboratory testing than the Navajo.

5. Traditional measurements of temperature susceptibility of penetration index (PI) and penetration-viscosity number (PVN) while apparently able to identify performance differences for the unmodified asphalts do not appear to be able to predict performance adequately for the polymer modified asphalts.

8. References

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